

An Overview of FAA Fire Safety R&D Since the Previous Triennial Conference

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FAA Wm. J. Hughes Technical Center
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The 7th Triennial International Fire & Cabin Safety
Research Conference
December 2 – 5, 2013
Philadelphia, PA



**Federal Aviation
Administration**



Program Overview

- **The Fire Research and Safety program develops the enabling technology to prevent accidents caused by in-flight (main emphasis of current program) and to improve survivability during a post-crash fire.**



Program Drivers

- **Fire Accidents**
- **Incidents**
- **NTSB Recommendations**
- **New Technology**
- **New Fire Threats**
- **EPA Restrictions**



Fire Safety of New Material Technology

- Determine the adequacy of present regulations and advisory material as it applies to new technology materials in aircraft (e.g., composite fuselage and wings)
- Where necessary, develop new test protocols and/or guidance materials.
- Drivers:
 - New test methods would obviate the need for Special Conditions in new composite aircraft
 - New lightweight magnesium alloys are fire resistant

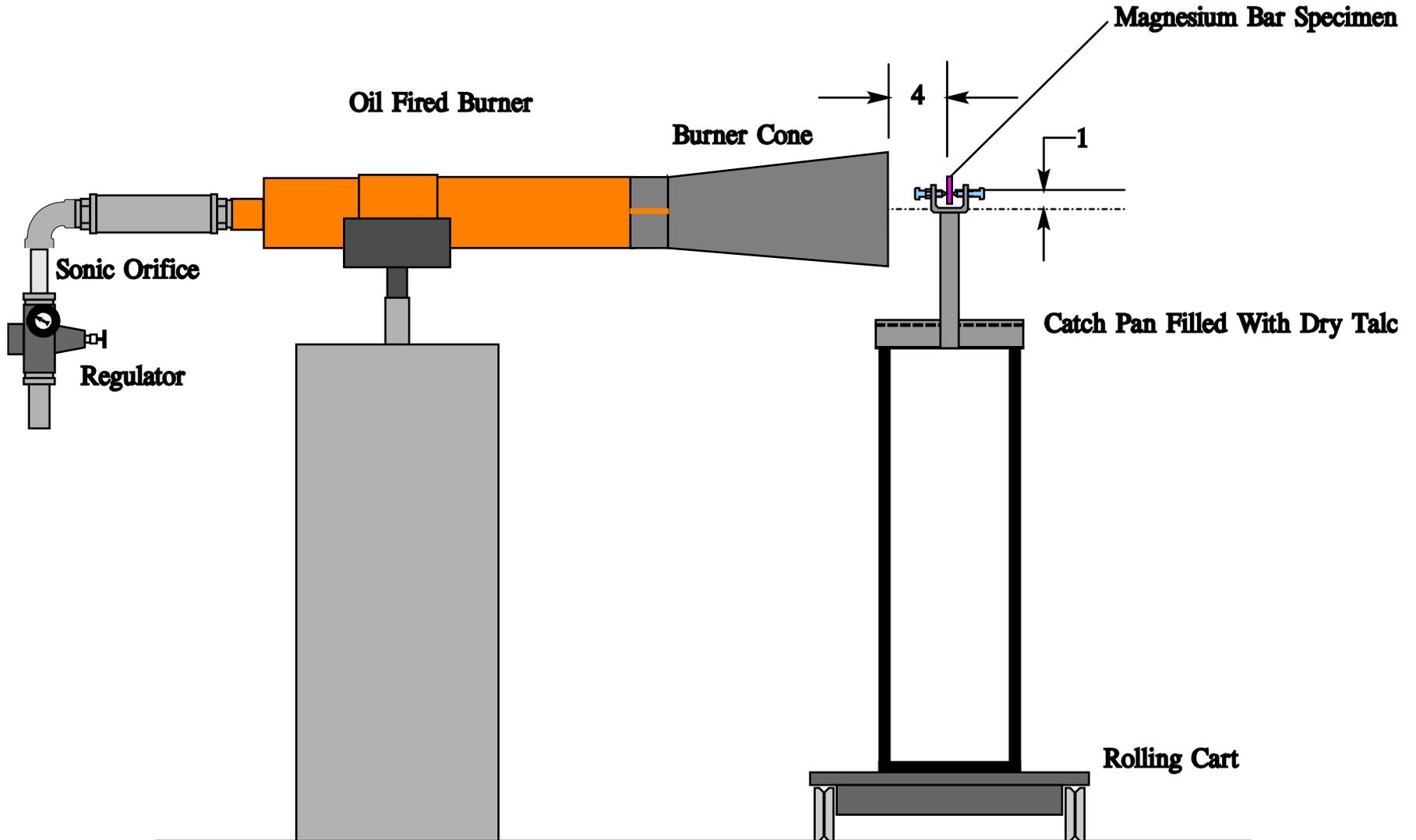


Fire Safety of New Material Technology

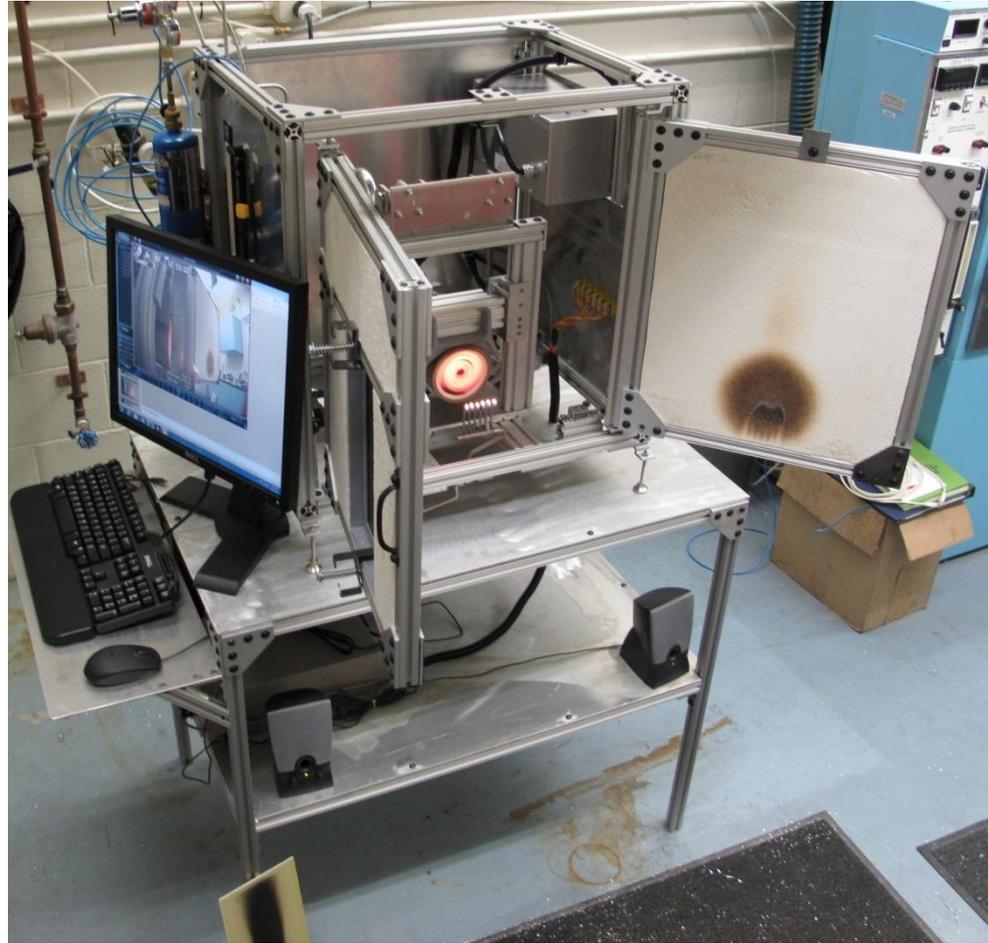
- **Major Accomplishments**

- Developed a flammability test method and criteria for magnesium alloy seat structure under postcrash fire conditions
- Developed a new prototype flammability test method for composite fuselage materials under in-flight fire conditions
- Developed a test apparatus to measure toxic gas emissions from burnthrough resistant fuselage materials under postcrash fire conditions

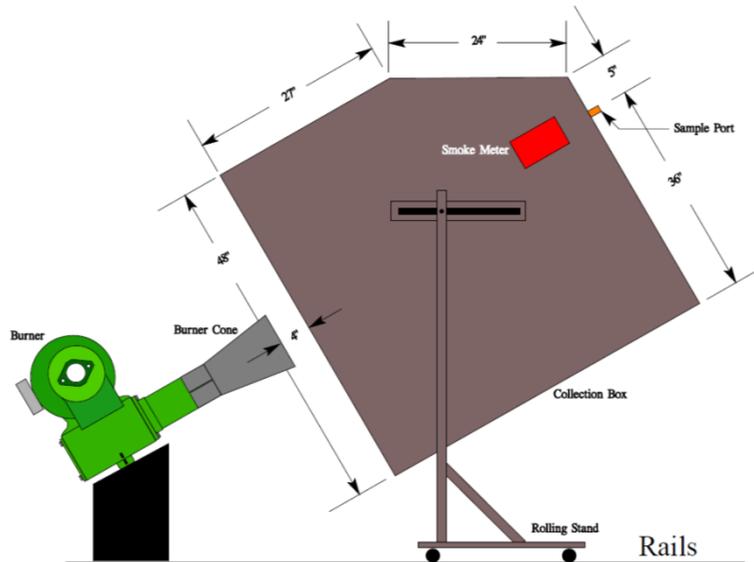
Flammability Test Method for Magnesium Seat Structure



Flammability Test Method for Composite Fuselage Materials



Toxic Gases Hazard Inside a Burnthrough Resistant Fuselage During a Postcrash Fire



**Intermediate Scale
Test Apparatus**



**Large-Scale Test of
Composite Material**

**FAA Report:
DOT/FAA/AR-09/58**

Improve Existing FAA-Required Material Flammability Test Methods

- Supports both FAA and Industry in solving problems encountered with present regulatory/advisory material
- Cooperative effort through International Aircraft Materials Fire Test Working Group
- Drivers:
 - Complexity of fire test standards
 - Inherent fire variability and need for improved test reproducibility
 - High cost burden to industry
 - Planned proposed rulemaking to revamp FAA flammability regulations



Improved Existing FAA-Required Material Flammability Test Methods

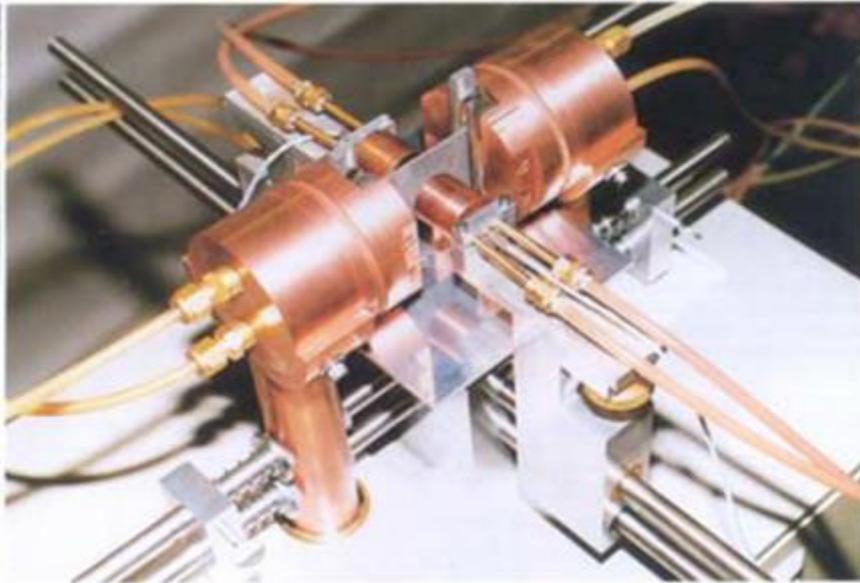
- **Major Accomplishments**

- Progress in improved standardization of all test methods
- Developed an aviation heat flux calibration standard
- Initiated substantive improvements in OSU Heat Release Rate Test
- Effort to replace “oil burner” with NexGen Burner and Flame Retention Head in Seat Cushion and Cargo Liner Test Methods
- Support for Industry activity to standardize and improve Means of Compliance (MOC)

Improvements in Existing FAA Flammability Test Method

- **Cabin Materials OSU Heat Release Rate Test**
- **Seat Cushion Oil Burner Test**
- **Cargo Liner Oil Burner Test**
- **Thermal Acoustic Insulation Oil Burner Test**
- **Thermal Acoustic Insulation Radiant Panel Test**
- **Evacuation Slides Radiant Heat Test**
- **Cabin Materials Vertical Bunsen Burner Test**

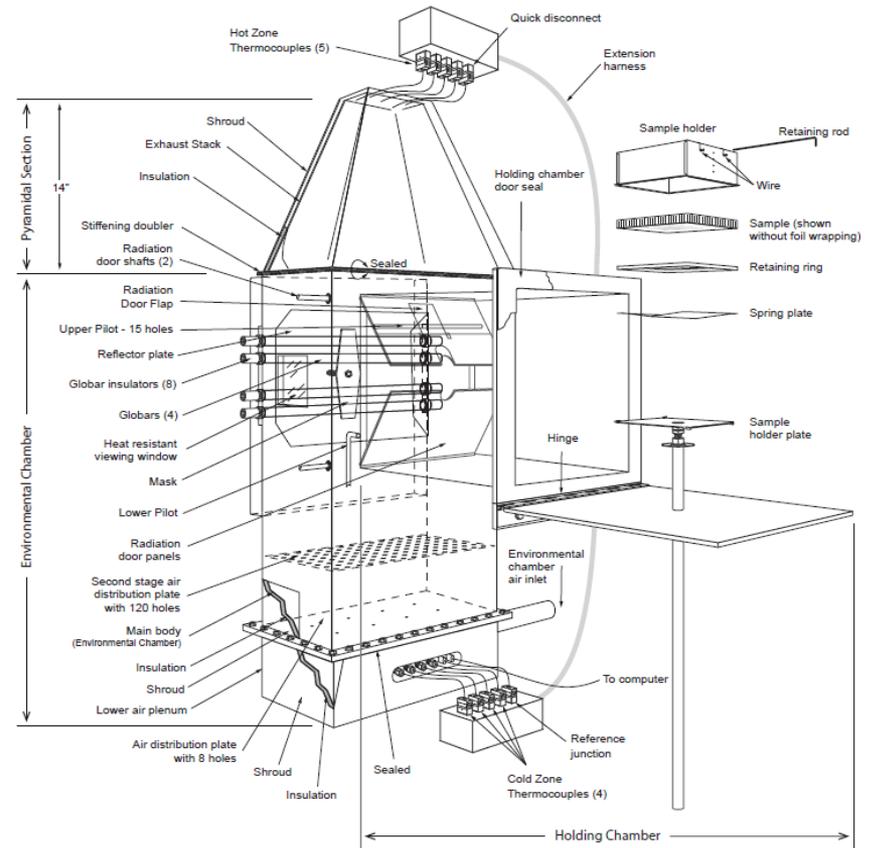
Developed an Aviation Heat Flux Calibration Standard



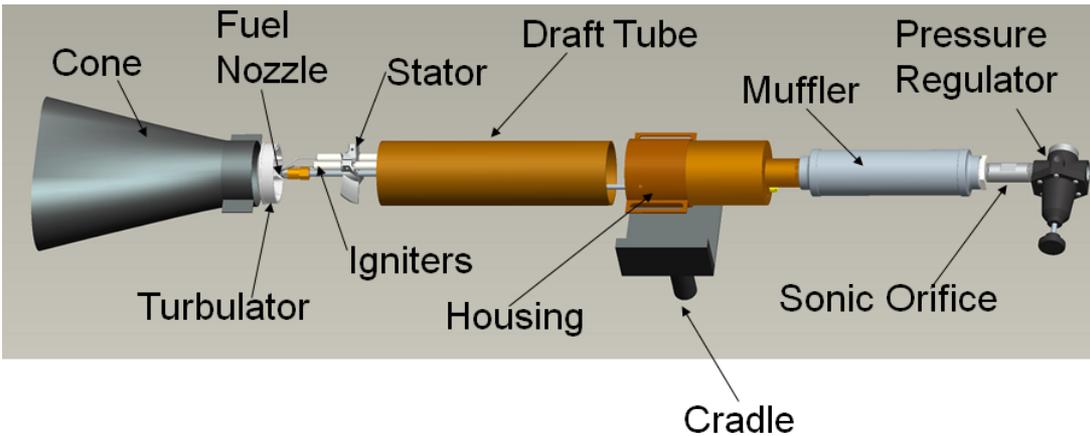
- A standard technique for calibrating heat flux transducers
- Transferable to National Institute of Standards and Technology (NIST) primary heat flux transducer
- Consists of reference heat flux transducer, radiant heat source and precision alignment system

Initiated Improvements in OSU Heat Release Rate Test (HR2)

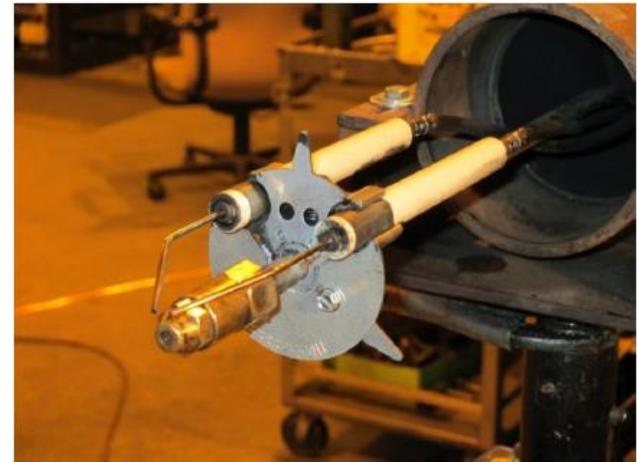
- **Replace exhaust stack**
 - Eliminates bypass air
- **Improve heat release rate calibration sequence**
- **Standard calibration burner location**



Replacement and Improved Burner in Seat Cushion and Cargo Liner Test



NexGen (Sonic) Burner



Flame Retention Head

Standardize and Simplify Methods of Compliance Across Industry for Material Flammability Tests (OSU and VBb)



U.S. Department of Transportation
Federal Aviation Administration

Policy Statement

Subject: Flammability Testing of Interior Materials **Date:** August 16, 2012 **Policy No:** PS-ANM-25.853-01

Initiated By: ANM-100

Summary

This policy statement provides guidance on acceptable methods of compliance with the flammability requirements of Title 14, Code of Federal Regulations (14 CFR) part 25 for commonly constructed parts, construction details, and materials. The methods of compliance discussed in this policy apply to Amendment 25-32 and later for § 25.853(a) and Amendment 25-61 and later for § 25.853(d). In addition, where the same test method is used to meet other requirements, such as special conditions, or § 25.855, these methods of compliance (MOC) also

DOT/FAA/TC-12/10

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

Flammability Standardization Task Group—Final Reports: Federal Aviation Administration Draft Policy Memo, AMN-115-09-XXX, August 20, 2009

September 2012
Final Report

This document is available to the U.S. public through the National Technical Information Services (NTIS), Springfield, Virginia 22161.

This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.



U.S. Department of Transportation
Federal Aviation Administration

Halon Replacement

- Evaluate potential replacement agents and systems and provide technical guidance for the safe conversion to environmentally friendly fire suppression and extinguishing agents for use on aircraft.
- **Drivers:**
 - ICAO and European Commission mandates to replace halon
 - Halon contamination

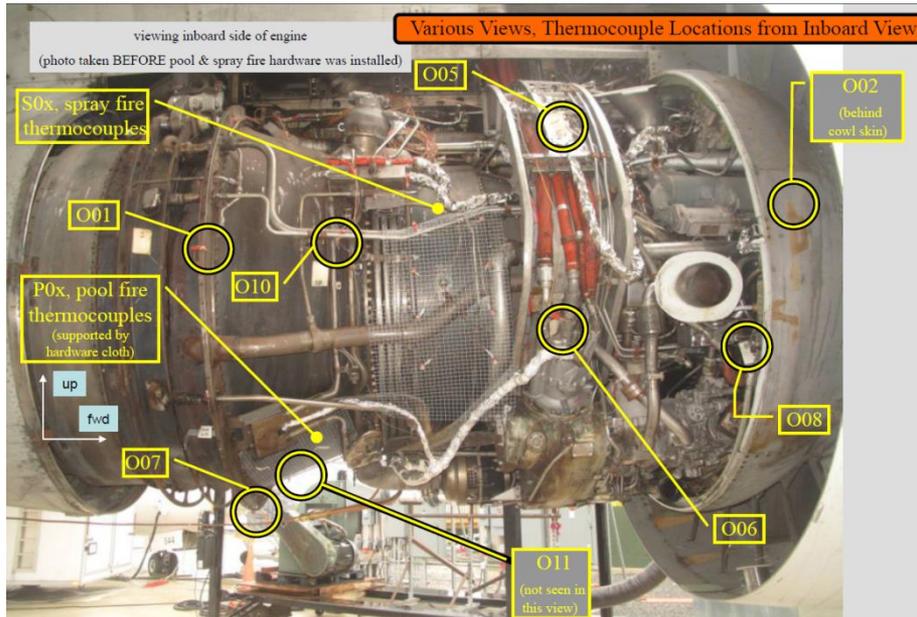


Halon Replacement

- **Major Accomplishments**

- Evaluated solid aerosol extinguishing agent in an aircraft engine nacelle
- Evaluated impact of low ambient temperature on effectiveness of candidate engine fire extinguishing agent
- Developed criteria for the safe use of hand-held extinguishers, including the effect of agent stratification
- Supported hand-held extinguisher optimization using a SNAP-listed agent

Evaluated Solid Aerosol Extinguishing Agent Against Fires in an Aircraft Engine Nacelle

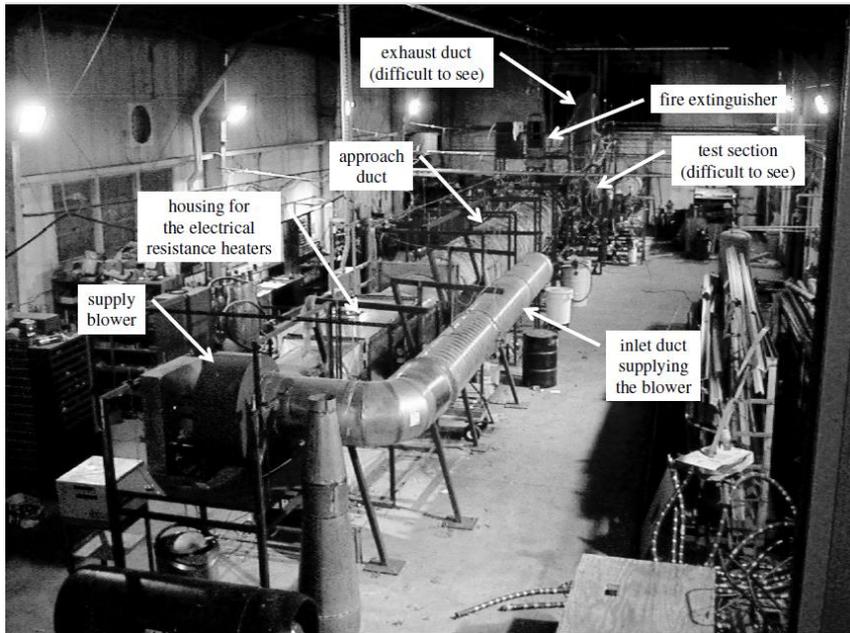


747SP Engine Test

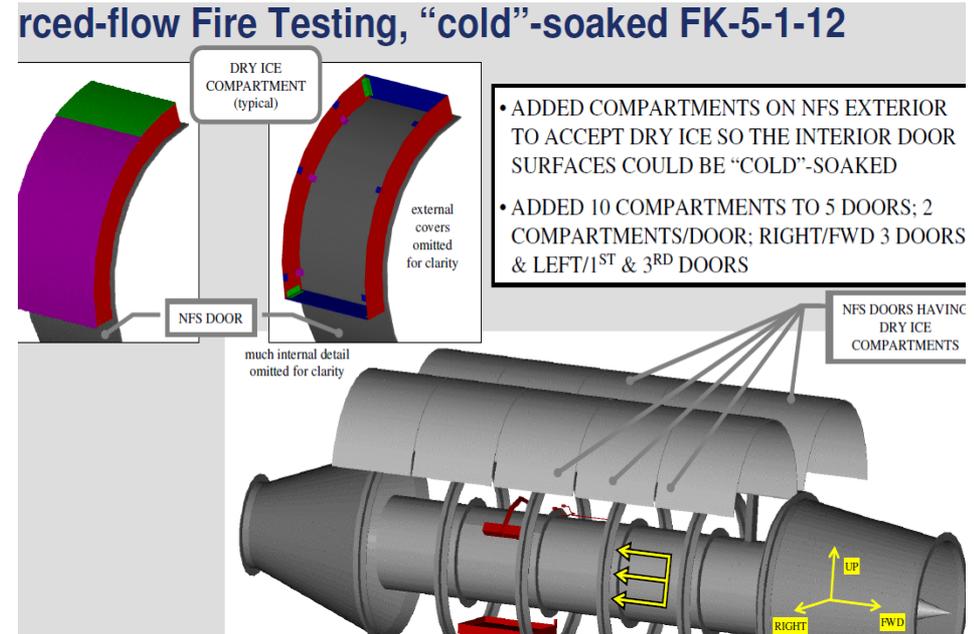


Spray Fire Visual Results

Impact of Low Temperature on Volatile Extinguishment Agent in Engine Nacelle Fire Simulator



Engine Nacelle Fire Simulator



Modified ENFS for Cold-Soaked Tests

Developed and Issued Criteria for Safe Discharge of Hand-Held Extinguishers in Aircraft



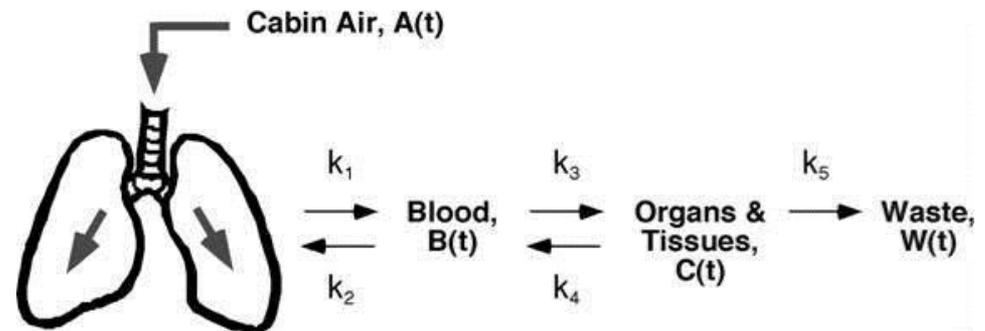
U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Hand Fire Extinguishers for use in Aircraft Date: 01/14/11 AC No: 20-42D
Initiated by: AIR-120 Change:

This advisory circular (AC) gives you guidance for the fire-fighting effectiveness, selection and safe-use of hand fire extinguishers in airplanes and rotorcraft. In it we will also show you how to gain Federal Aviation Administration (FAA) approval of hand fire extinguishers for aircraft.

Susquanna Cobler
For: David W. Hempe
Manager, Aircraft Engineering Division
Aircraft Certification Service



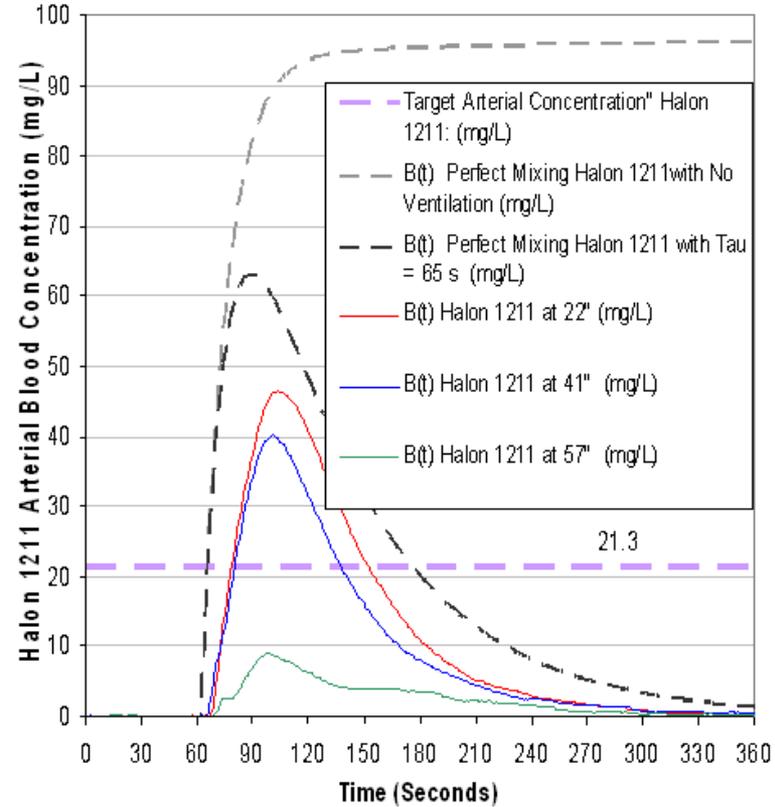
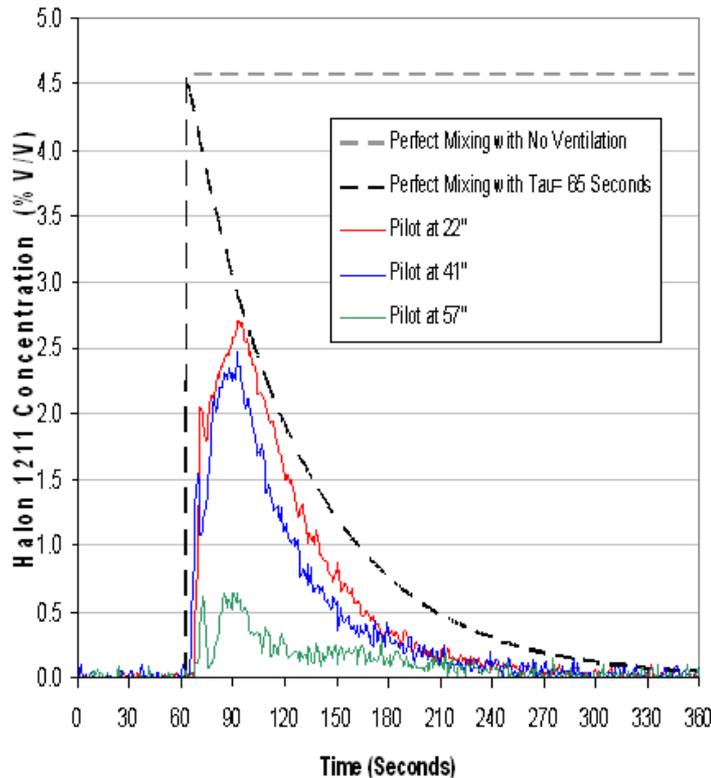
Kinetic Model of Halocarbon Transport in the Body

Journal of Inhalation
Toxicology, 2010, 1 – 11

Determined Impact of Stratification on Safe Discharge of Halon 1211

Flight Deck Test 1: Target: Copilot's Window Heater

MF Stratification & Localization = 1.36, 1.57, 6.99, (22", 41", 57")
 Based on Halon 1301 kinetics



Progress on Hand-Held Extinguisher Optimization



- Employs patented mist generation technology and Novec 1230
- Meets FAA MPS Hidden Fire Test
- Meets 3B pan/Heptane Fire
- Meets 5B pan/JP-8 fire (4 lbs)
- **Goal**: Develop a hand-held extinguisher that meets 5B pan/Heptane fire with 4 lbs of agent and FAA MPS tests

Freighter Fire Safety

- **Determine the adequacy of current fire safety requirements in freighter aircraft and the feasibility and cost/benefit of fire detection and suppression improvements.**
- **Drivers:**
 - Freighter hull losses and serious incidents caused by fire
 - NTSB recommendations related to (1) adequacy of current detection means and (2) need for an on-board fire suppression system



**UPS 747-400
Dubai
9/3/2010**

Freighter Fire Safety

- **Major Accomplishments**

- Developed a risk model of likely freighter fire accidents and their cost over 10 years
- Developed a cost/benefit model framework for freighter fire mitigation strategies over a 10 year period
- Demonstrated the effectiveness of UPS fire resistant cargo container with and without aerosol extinguishing agent
- Supported ISO/SAE development of fire containment cover (FCC) and fire resistant container (FRC) standards by SAE and ISO.
- Determined the relationship between burning rate and atmospheric pressure and oxygen concentration

Freighter Fire Accident Risk Analysis Model (DOT/FAA/AR-11/18)

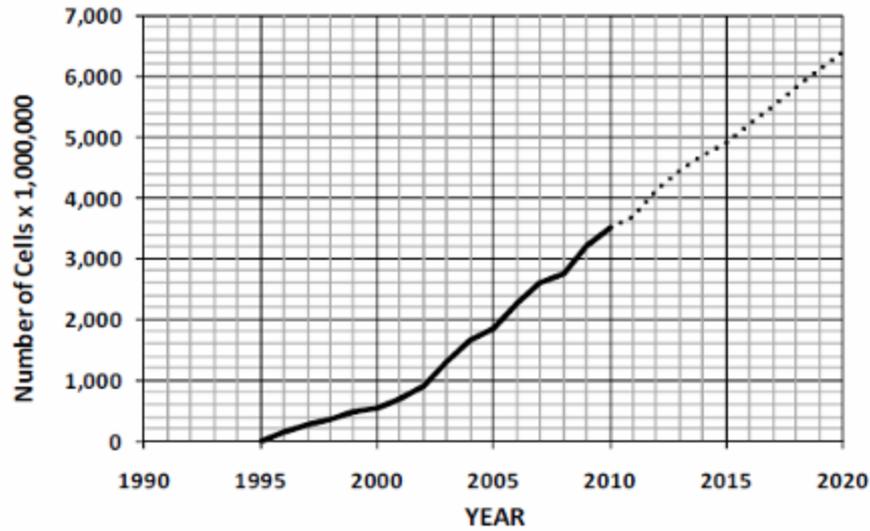


Figure 3 Estimation of the Annual Number of Lithium Ion batteries produced worldwide

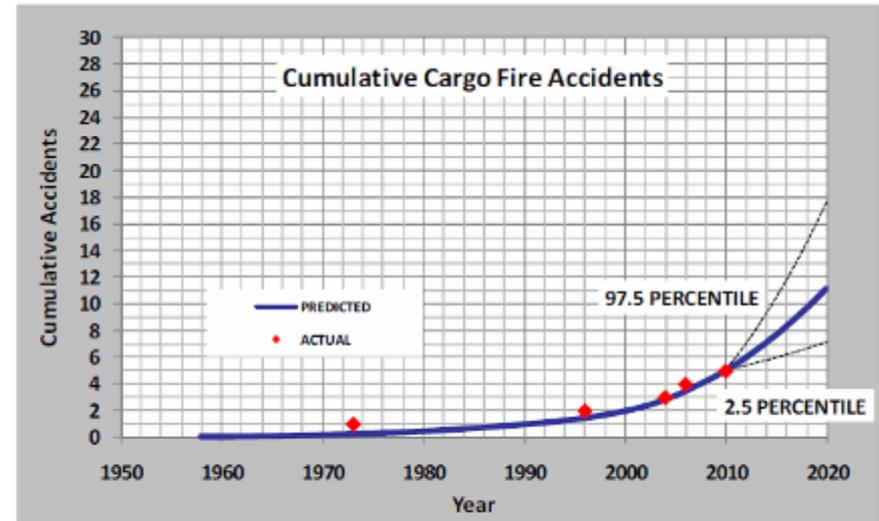


Figure 6 Predicted Number of Freighter Airplane Cargo Fire Accidents through to 2020

Freighter Cost/Benefit Model Framework for Fire Mitigation Strategies

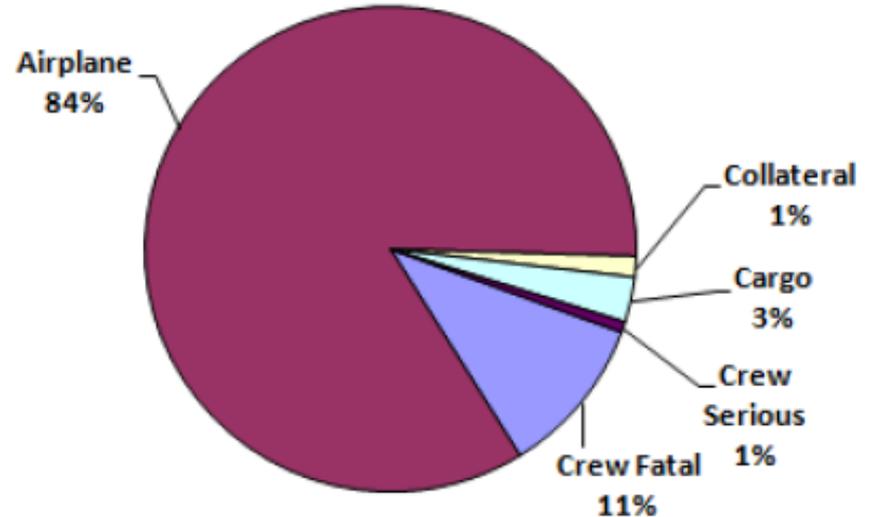
(DOT/FAA/TC-13/2)

Mitigation

All None

- CONTAINER SUPPRESSION - EXTERNAL
- CONTAINER SUPPRESSION - INTERNAL
- PALLET COVERS
- BATTERY BOXES PRIMARY
- BATTERY BOXES SECONDARY
- FIRE HARDENED CONTAINERS
- COMPARTMENT SUPPRESSION

Accident Cost Breakdown: Average for Selected Airplanes - Prior to Mitigation



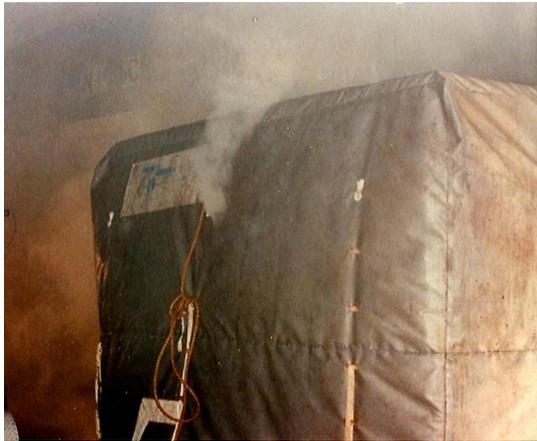
Effectiveness of Fire Resistant Cargo Container and Aerosol Extinguishing Agent

Composite Test Article



- UPS lightweight fire resistant cargo container suppresses fire by oxygen starvation for 4 hours
- Early discharge of aerosol agent provides additional protection
 - May extinguish fire
 - Reduces likelihood of a flash fire when container is opened
- Rapid extinguishment/suppression can prevent fire spread to hazardous cargo (e.g., lithium batteries)
- UPS introducing fire resistant cargo containers into service trials

SAE/ISO Standards Development Participation



FCC

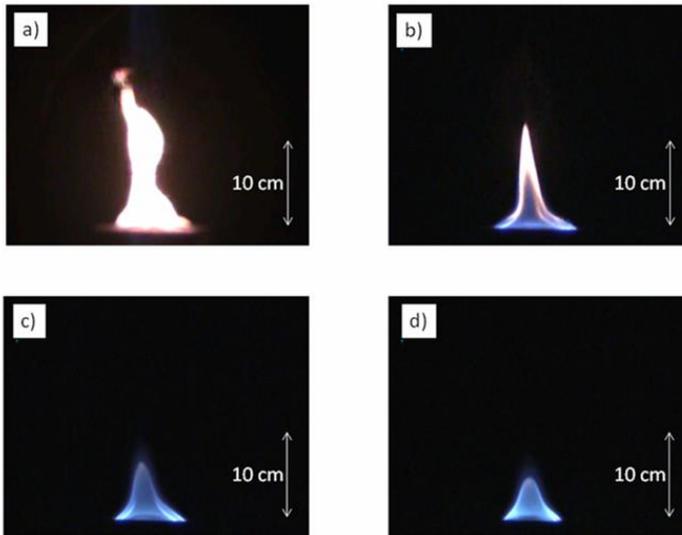


FRC

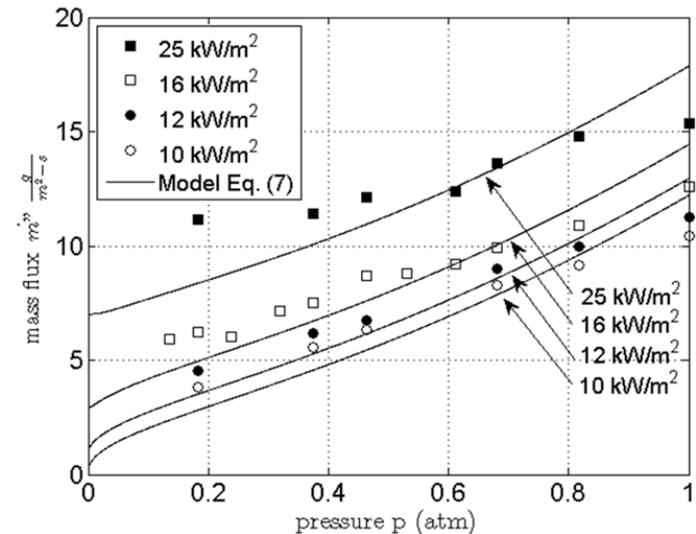
- The FAA requested SAE develop new standards for Fire Containment Covers (FCCs) and Fire Resistant Containers (FRCs) for improving fire protection on freighter aircraft.
- ISO is also developing similar standards in a parallel effort.
- The FAA plans to issue or revise a Technical Standard Order (TSO) that will reference these new standards
- The Fire Safety Branch has conducted full scale testing and provided input to SAE/ISO to support these new standards

Effect of Pressure and Oxygen Concentration on Material Burning Rate

Flame Profiles at a) 1 atm, b) 0.6P atm, c) 0.47 atm, d) 0.18 atm



Steady Burning Mass Flux vs Pressure at Different Heat Fluxes – Experiment and Theory



**Combustion &
Flame 160 (2013)
1519 - 1530**

Lithium Battery Fire Hazards

- **Determine the fire hazards of lithium batteries and develop methods to prevent or control**
- **Applications: bulk transport as cargo; aircraft application, including cabin; passenger carry-on, and passenger luggage**
- **Drivers:**
 - Fatal freighter fire accidents
 - Increasing rate of incidents in aviation
 - Billions of lithium batteries transported annually by air
 - Transport of batteries increasing faster than all other cargo combined



Lithium Battery Fire Hazards

- **Major Accomplishments**

- Evaluated hazards in freighter main cargo compartment under full-scale fire conditions (B727)
- Demonstrated cockpit smoke obscuration from electronic flight bag (EFB) with batteries in thermal runaway (B737)
- Evaluated effectiveness of a Halon 1301 fire suppression system in Class C cargo compartment under full-scale fire conditions (B727)
- Examined improvements in bulk shipment packaging aimed at preventing propagation of thermal runaway
- Determined the effectiveness of different agents in extinguishing a battery fire and preventing thermal runaway propagation, under small-scale fire conditions

Lithium Battery (5000 Cells) Fire Hazards in Freighter Main Cargo Compartment (Class E)



- **Lithium Ion Batteries**
 - Smoke obscuration in flight deck
 - Significant compartment damage
 - Test terminated before all cells consumed
- **Lithium Metal Batteries**
 - Faster fire growth and greater hazards than lithium ion test
 - Smoke obscuration in flight deck
 - Test terminated in 16 minutes
- **Non-Lithium Batteries**
 - No smoke in flight deck
 - Minimal damage to cargo liners
 - Test terminated after more than one hour because of steady conditions



Cockpit Smoke Caused by EFB Thermal Runaway



- Heavy smoke in cockpit greatest hazard
- CO, CO₂, O₂ depletion and temperature rise insignificant
- High cockpit ventilation (1 air change per minute) did not prevent smoke obscuration
- Halon extinguished open flames but did not prevent cell-to-cell propagation and smoke/gas emissions

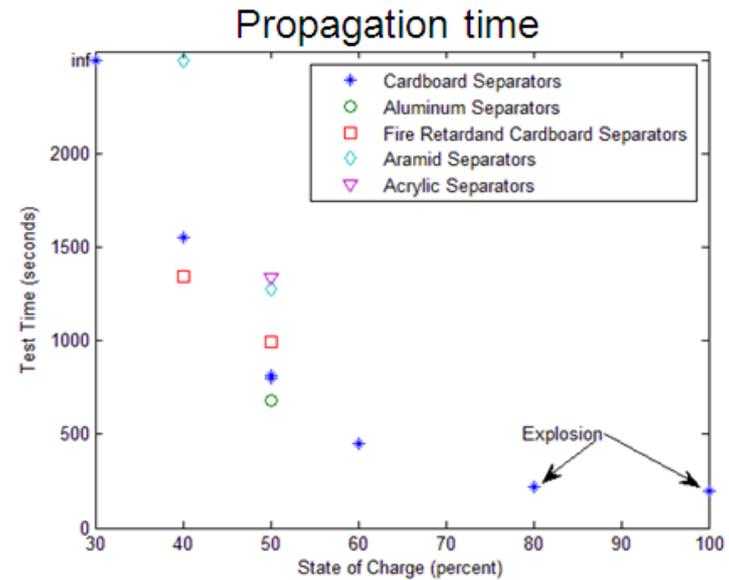
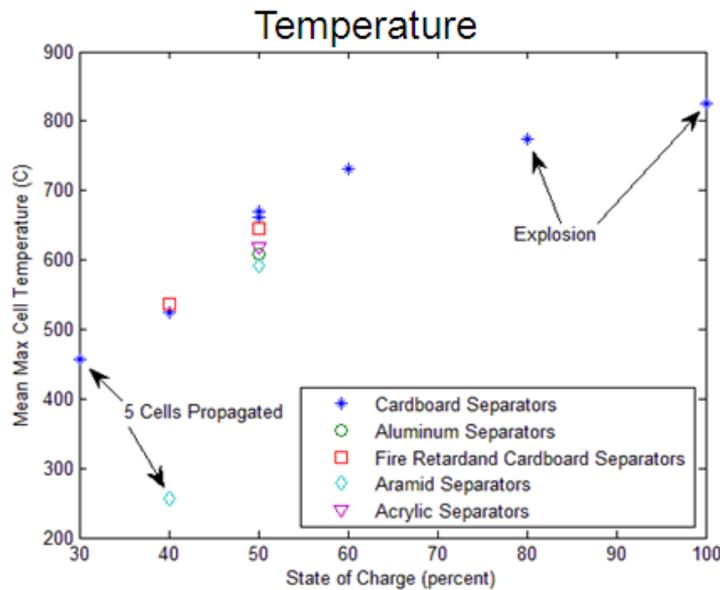
Lithium Battery (5000 Cells) Fire Suppression in Class C Cargo Compartments



- **Lithium Ion Batteries**
 - Extinguished open flames
 - Did not prevent thermal runaway propagation
 - No smoke penetration into flight deck or main cargo compartment
- **Lithium Metal Batteries**
 - Fire continued to escalate despite halon and oxygen depletion
 - Heavy smoke in main cargo compartment and adjacent mixed bay
 - Test was terminated with water
 - Explosion occurred after termination
- **Non-Lithium Batteries**
 - Fire suppressed
 - Smoke confined to cargo compartment
 - No damage to aircraft

Examination of Passive Improvements for Bulk Shipment Packaging

Lithium-ion Results (State-of-Charge)

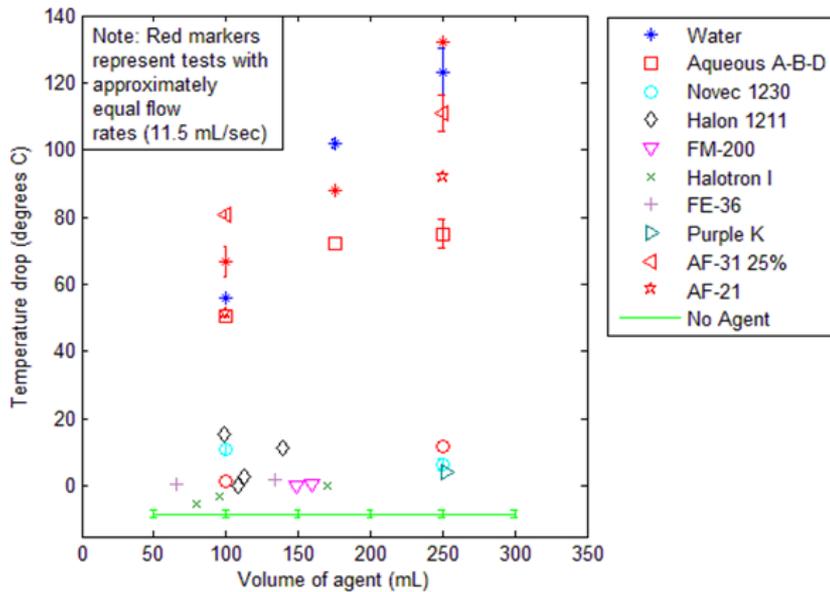


40% state-of-charge, fire retardant cardboard

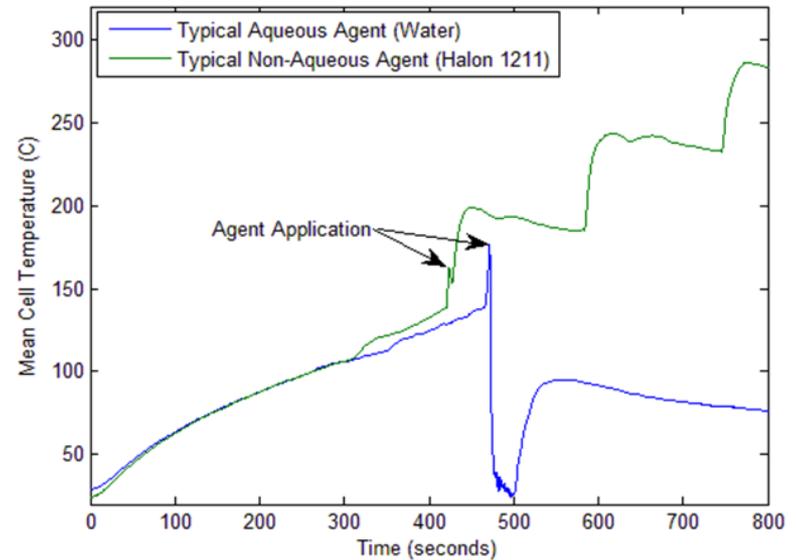
50% state-of-charge, fire retardant cardboard

Effectiveness of Streaming Agents

Extinguishment and Prevention of Thermal Runaway Propagation



(a)



(b)

Additional Information: www.fire.tc.faa.gov



Federal Aviation
Administration
Fire Safety

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What's New

Date	Section	Description
10/22/13	Reports	Added report DOT/FAA/TC-13/46
10/21/13	Reports	Added report DOT/FAA/TC-12/13
10/04/13	Materials	Added September 2013 HR2 Task Group Meeting files.
08/22/13	Conference	Added abstracts and author biographies.
07/22/13	Materials	Minutes and attendee list posted from June meeting.
07/02/13	Materials	Presentations posted from June meeting.
6/07/13	Systems	Presentations, minutes, and attendee list posted from May meeting.
5/17/13	Handbook	Updated Appendix F and Chapter 6
5/14/13	Materials	June meeting agenda posted.
5/14/13	Systems	Update the May meeting agenda .
5/09/13	Systems: Lavex: Lavex MPS	Updated Lavex Minimum Performance Standard
4/12/13	Reports	Added Report DOT/FAA/TC-13/2
4/05/13	Reports	Added report DOT/FAA/TC-12/53
3/29/13	Systems	May meeting info updated and agenda posted.
3/19/13	Materials	Presentations, minutes, and attendee list posted from March meeting.
2/05/13	Reports	Posted reports DOT/FAA/AR-11/3 and DOT/FAA/TC-12/39
1/30/13	Systems	May meeting info posted and registration open.
1/30/13	Materials	March meeting agenda posted.
1/21/13	Handbook	Updated Appendix F & Appendix G
1/17/13	Materials	June meeting info posted and registration open.
1/16/13	Materials	March meeting info posted and registration open.
12/13/12	Front Page	Posted 2012 FAA Fire Safety Highlights .
11/27/12	Systems	Presentations, minutes, and attendee list posted from Nov. meeting.
11/06/12	Systems	Updated agenda for Nov. meeting (includes ICAO agenda)

Additional Links and Information

[Final AC on Thermal/Acoustic Insulation Burnthrough.](#)
[AC 25.856-2A Installation of Thermal/Acoustic Insulation for Burnthrough Protection](#)

[Amendment to Fire Penetration Resistance of Thermal/Acoustic Insulation Installed on Transport Category Airplanes](#)

[Datasheet for Round Robin for the Heat Release Test \(OSU\) and Smoke Density Test \(NBS\)](#)

Announcements

Update: [Heat Release Rate Apparatus](#)

SAFO: [Risks in Transporting Lithium Batteries in Cargo by Aircraft](#)

Final Policy: [Policy Statement on Flammability Testing of Interior Materials Issued](#) (link opens small window)

UPDATED 08/12: [Statement on the Use of Magnesium in Airplane Cabins](#)

Released: [AC 20-42D - Hand Fire Extinguishers for Use in Aircraft](#)

Cabin Safety Research Technical Group: [Accident Database](#) now available online.

Info: [Availability of a Federal Aviation Administration \(FAA\) In-flight Firefighting Training Video](#) (see VIDEOS below)

SAFO: [Fighting Fires Caused By Lithium Type Batteries in Portable Electronic Devices](#) (see VIDEOS below)

VIDEOS: [View videos on Cabin Crew Fire Fighting Training](#) (updated 03/09/09) & [Laptop Battery Fires](#).

Highlights

- [2012 Highlights](#)
- [2011 Highlights](#)
- [2010 Highlights](#)
- [2009 Highlights](#)

